Micro Economic Explanations of Structural Change and Growth

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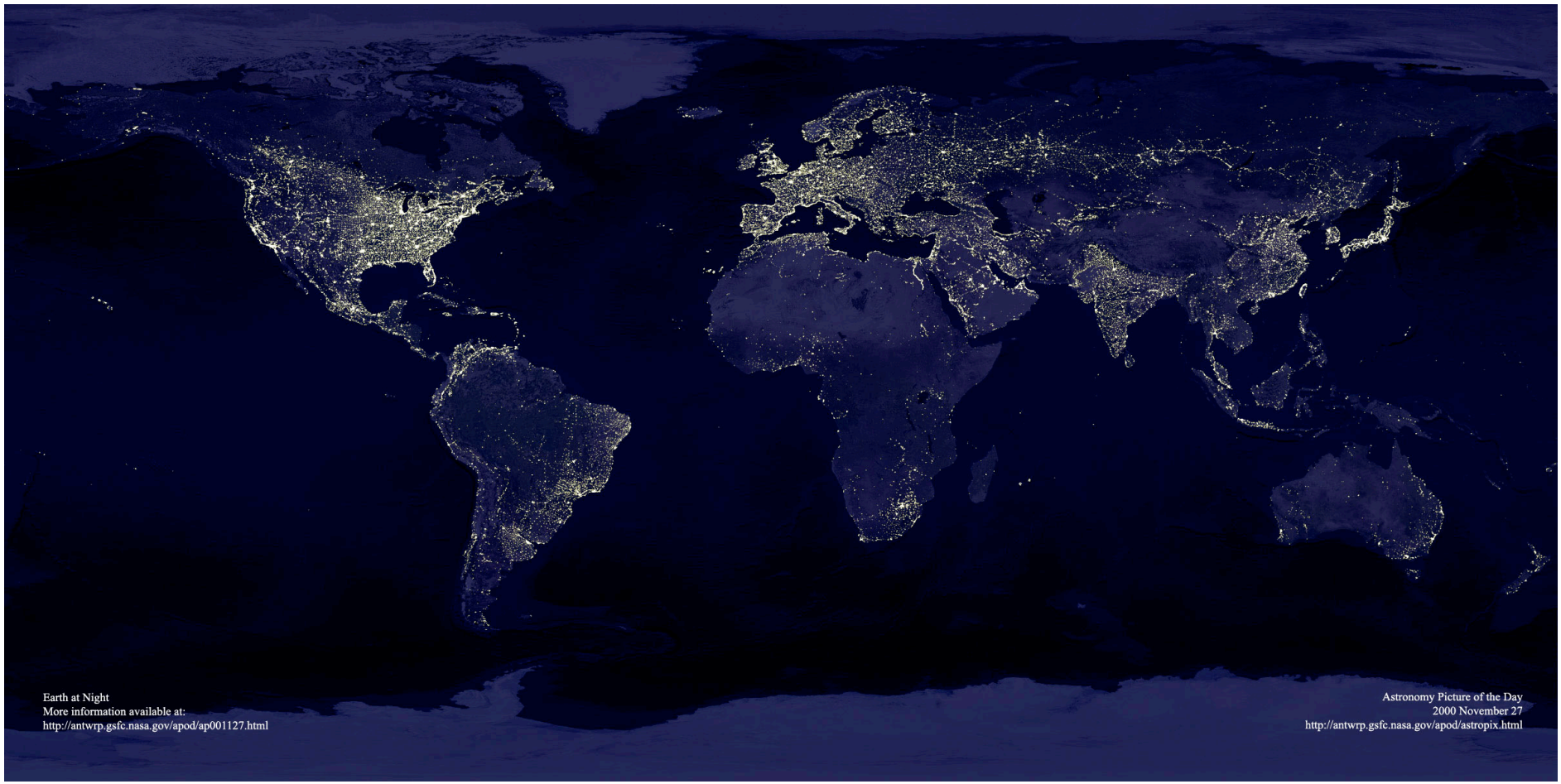
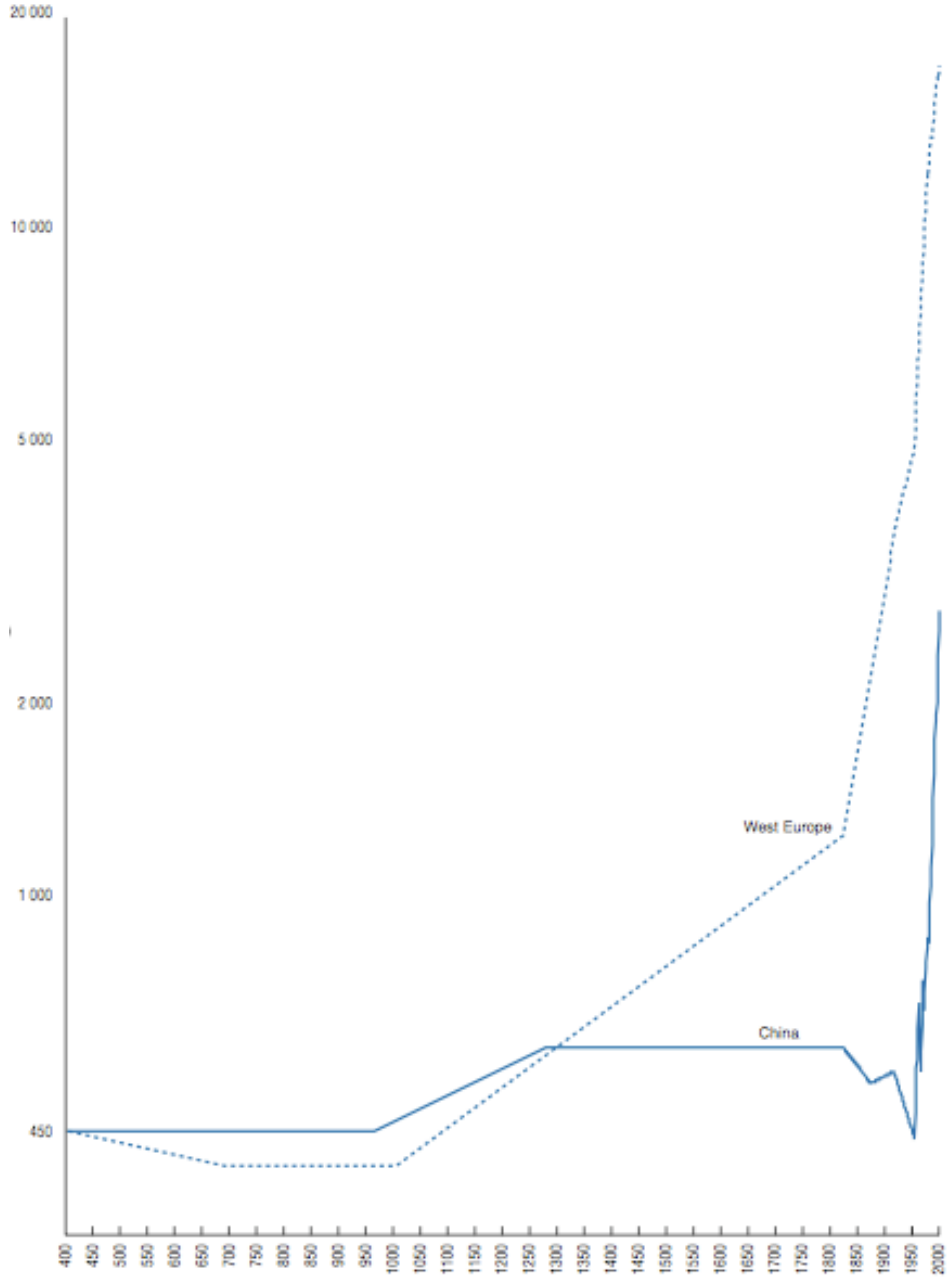
World income: a static picture



World income: a millennial perspective

Figure 1-4. **Comparative Levels of GDP Per Capita: China and West Europe, 400-1998 A.D.**



Learning objective of this workshop

By the end of this workshop we should be able to provide a tentative answer — or problematise — the following questions:

- What do we mean by structural change?
- How does it affect and is affected by long run patterns of growth? And how has this question being addressed in the growth literature?
- How can we model the micro interactions underlying processes of structural change? And how does it help to understand this relation at the macro level?

Outline of the presentation

1. Introduction
   - Definitions and dimensions of structural change
   - Long term growth: explanatory factors and evidence
2. Synthetic models of growth *cum* structural change
   - Structural change and productivity
   - An augmented Unified Growth Theory model
3. A microeconomic model of supply and demand structural coevolution
4. Simulation results: aggregate properties, sector dynamics, and micro causes
   - The effect of structural dimensions
5. Summing up and final considerations

Interpretations of structural change

- The standard interpretation [Fisher, 1939]: three sector split model: Agriculture $\longmapsto$ Manufacture $\longmapsto$ Services (SC Figure)
- The industrialisation interpretation [Kuznets, 1966, Chenery and Syrquin, 1989]: industrialisation is at the core of growth and development
  - Growth policy for decades (Marshall plan, planned economies, Rosenstein-Rodan, urban bias)
  - Migration from rural to urban areas (Lewis, Harris, Todaro)
  - Kaldor Verdoorn law

Interpretations of structural change II

- The development interpretations
  - Division of labour and functional distribution: Smith
  - Development stages [Rostow, 1960] (Traditional society $\rightarrow$ Precondition to take-off $\rightarrow$ Take-off $\rightarrow$ Maturity $\rightarrow$ High Mass Consumption) and Marx
  - Terms of trade and the Prebish-Singer hypothesis: product specialisation

... ...

Tentative definitions

Matsuyama 2008, *New Palgrave Dictionary of Economics*

[...] complementary changes in various aspects of the economy, such as the *sector compositions of output and employment*, the *organization of industry*, the *financial system*, *income and wealth distribution*, *demography*, political *institutions*, and even the society's *value system*

Saviotti and Gaffard 2008, *JEE*

In a systemic framework, structural change can be defined as a change in the structure of the economic system, that is, in its *components* and in their *interactions*. Components are [...] *particular goods or services*, and other activities and *institutions*, such as *technologies*, *types of knowledge*, *organizational forms* etc.
What does it mean for a system to be in equilibrium when its composition keeps changing due to the emergence of qualitatively different entities?

Determinants of long run growth differences?

- International economic order [Bairoch; Landes; Galeano; ...]
- Organisation of production [Marx; Lazonick; von Tunzelman; ...]
- Technological progress: paradigmatic and incremental (including technological races) [Freeman; Mokyr; Rosenberg; ...]
- Consumption [Maddison; Berg; ...]
- Institutions and organisations: rules of the game [North; Dixit; Boeetke; Rodrick; Chang; Sokoloff; ...]
- 'Cultural beliefs' and institutional structure [Polany; Greif; ...]
- Non economics: culture [McCloskey]

Causality

Which of these dimensions comes first and is necessary (or not) for the other ones to occur? How do they relate with one another?

Empirical evidence of long run growth: industrial revolution in England

1. Slow increase in productivity and output
2. Stagnant living standards, slow increase in wages
3. Increasing pop: mass of unskilled workers (demand) and increasing household productivity in agriculture
4. Higher minimum wages
5. Increase in market size: shift to high income elasticity goods/sectors
   - Slow change in sectoral composition
6. Irrelevance of human capital
7. Increase in firm size and organisation of labour

Source: [Voth, 2003, Voigtländer and Voth, 2006, Desmet and Parente, 2009, Berg, 2002, Mokyr, 1992]

Empirical evidence of long run growth: industrial revolution in England

8 Innovation: small innovators turning ideas into prototypes:
- no IPR and monetary incentives
- cumulative process
- entrepreneurs

9 Not only process innovation to increase productivity
- New product demand driven: changing tastes, not prices

Source: [Voth, 2003, Voigtländer and Voth, 2006, Desmet and Parente, 2009, Berg, 2002, Mokyr, 1992]

Caveats

- Observation of economic relations: deepest causes? [Abramovitz, 1986]
- How are these dynamics related and why in the UK?
- One particular case

Sum up: growth and structural change (in England)

- UK industrial revolution preceded by slow transformations. During the revolution the economy does not perform particularly well
- Production beyond subsistence is realised by a combination of factors, as well by chance
  - Each transformation alone is unlikely to have an impact
- Many of such transformations involve changes in the structure of the economy at the micro level
  - Population dynamics
  - Engel law and variety
  - Incentives for new goods
  - Incentive for new machinery: production factors relative price and labour control
  - Modes of production, organization of labour, hierarchical firm and specialisation

Productivity $\Rightarrow$ structural change: exogenous

Economy

Two sectors, **A**griculture and **M**anufacturing. Exogenous productivity changes

- Employment in A $\downarrow$ as productivity in A $\downarrow$ relative to M: migration due to different marginal wages.
- Employment in A $\downarrow$ as productivity in A $\uparrow$ and higher relative demand shifts to manufacture (higher income elasticity): a few models with non homotetic preferences or hierarchical preferences.

Structural change $\Rightarrow$ productivity: endogenous

Economy

Two sectors, **A**griculture and **M**anufacturing. Productivity in M increases with **E**xperience. $E = f(n)$, with dE/dt changing sign for a critical n

- Higher productivity in A moves labour to M, increasing productivity.
- The extent of structural changes depends on the friction in moving labour between sectors
  - Unemployment risk
  - Limited migration (youth)
  - Credit constraint
  - Skill acquisitions
- Multiple equilibria and poverty traps: low initial productivity in M will never attract enough workers to initiate learning

Endogenous emergence of sectors

- Income inequality, innovation incentives, demand changes and non homotetic preferences [Matsuyama, 2002]
- Growth and diffusion of new goods with changing income structure [Aoki and Yoshikawa, 2002]
- Product diversification and different consumption classes: coexistence of mass consumption and luxury goods [Bertola et al., 2006, Falkinger and Zweimüller, 1997]
- New goods with changing position on a hierarchy of needs (good specific) [Föllmi and Zweimüller, 2008]

A Unified Growth Theory model *cum* structural change

Based on: Desmet K. & S. Parente, 2009. The evolution of markets and the revolution of industry: A quantitative model of England's development, 1300-2000, *Instituto Madrileño de Estudios Avanzados (IMDEA) Ciencias Sociales WP*

- Unified growth theory model (models of the transition from Malthusian to modern growth)
- Two sectors: agriculture and manufacturing
- Household leave one period: utility depends on goods consumption, and children
- Rural and urban population with different income and consumption preferences over an increasing set of manufacturing goods

A Unified Growth Theory model *cum* structural change

- Process innovation increase productivity in manufacturing
- Productivity in agriculture increase exogenously
- Market size is also function of the number of products
- Changes in production and competition affect firm size and mark-up
- Innovation linked to firm size and competition

D&P: 2009 Dynamics

- Initial period in pre Malthusian setting: mainly agriculture
- Very low variety of manufacturing goods
  - Low competition $\Rightarrow$ large mark-up $\Rightarrow$ small firms
  - $\Rightarrow$ Low innovation
- Slow exogenous TFP increase $\Rightarrow$ population $\uparrow$, urban pop $\uparrow$
- $\Rightarrow$ Firm size $\uparrow$ $\Rightarrow$ innovation $\Rightarrow$ endogenous productivity increase
- $\Rightarrow$ Fertility $\uparrow$ together with consumption $\Rightarrow$ demographic transition
- $\Rightarrow$ Agricultural employment share $\downarrow$ $\Rightarrow$ reduced fertility (higher cost of urban children)
- Convergence to constant innovation and growth

A micro founded model: purposes

Based on: Ciarli T. and A. Lorentz, 2010. Product Variety and Changes in Consumption Patterns: The Effects of Structural Change on Growth, Max Planck Institute of Economics, unpublished manuscript

- We take a quite different perspective
- Model the microeconomic mechanisms behind the structural changes, and their endogenous interactions
- No representative behaviour, market clearing, perfect mobility, exogenous dynamics
- Bounded rationality and information

A micro founded model: purposes

- Explicit relation between structural changes in supply and demand, economic growth & distribution
  - **S–1** Organisation of production [not only size]
  - **S–2** Technology of production [explicit capital structure]
  - **S–3** Composition of production [linked to changing consumption patterns]
  - **D–1** Income distribution [linked to compensation structure]
  - **D–2** Consumption patterns [linked to class composition evolution]

Theoretical Background

1. **Growth** follows an evolutionary process:
   - Supply side selection [Nelson and Winter, 1982, Silverberg and Verspagen, 2005, Metcalfe et al., 2006],
   - Demand and selection [Dosi et al., 1994, Verspagen, 2002],
   - Capital accumulation and vintages [Amendola and Gaffard, 1998],
   - Generation of product variety [Saviotti and Pyka, 2008]
   - Evolutionary Keynes [Dosi et al., 2010]
2. Patterns of **consumption** change with income *needs* satiation [Pasinetti, 1981, Witt, 2008, Witt, 2001]
   - Bounded rational consumer [Gigerenzer, 1997, Gigerenzer and Selten, 2001, Valente, 1999]
   - Lexicographic preferences

Theoretical Background II

3. Changes in production structure affect the **distribution of income** [Atkinson, 1997, Aghion et al., 1999, Galbraith, 1999]
   - Firms' organisation and wage tiers on income distribution[Simon, 1957, Lydall, 1959, Rosen, 1982]
4. **Methodology**: micro behaviour and generative processes [Akerlof and Shiller, 2009, Frydman and Goldberg, 2007]
   - Computational empirically based macro [Colander et al., 2008, Deissenberg et al., 2008, Howitt, 2006]

Basic model structure

- **Manufacturing firms**: product technology, process technology, labour organisation, R&D $\Longrightarrow$ product innovation (introduction of new sectors)
- **Capital suppliers**: R&D $\Longrightarrow$ capital vintage, labour organisation
- **Consumers**: preferences, consumer classes, expenditure shares across fixed needs
- **Wages setting**: min wage (macro), labour hierarchies, bonuses

[Short term dynamics]

Firms' production

- Each firm $f \in \{1; F\}$ produces one good, satisfying one consumer need $n \in \{1, 2, ..., N\}$ (= sector), with price (i_p) and quality (i_q).
- Output constrained by **labour** and **capital**:

$$Q_t = \min \left\{ Q_t^d ; A_{t-1} L_{t-1}^1 ; DK_{t-1} \right\}$$

  A_{t-1} is the labour productivity embedded in K vintages
- Price is determined as a fixed mark–up on variable costs
  - Firm organisations/size (**S-1**)
  - Labour productivity (**S-2**)

Factors of production: Labour

S–1 Organisation of production

- Demand for **first tier workers** L_t^1 adjusts to desired output and productivity.
- **Higher tiers** workers coordinate a batch of ν subordinates

$$L_t^2 = L_t^1 \nu^{-1}$$
$$\vdots$$
$$L_t^\Lambda = L_t^1 \nu^{1-\Lambda}$$

where Λ is the total number of firms' layers

Factors of production: Capital Stock

S–2 Technology of production

- Investment decision of new capital units is unconstrained, and has the priority in profits allocation
- Investment increases the efficiency of production

$$A_t = \sum_{\tau=0}^{t} \frac{k_\tau (1-\delta)^{t-\tau}}{K_t} a_\tau$$

δ: depreciation; a_τ: vintage productivity

- Capital good firms innovate improving the productivity of the supplied vintages proportionally to sales/profits: **stochastic R&D**
- Selection of capital goods firms: capital supply constraint

Product innovation

S–3 Composition of production

- **Spend** a fixed ratio of non invested profits ($R_{f,t}$) on R&D
- **Research** in a neighbourhood of the current sector/need n, limited by $\iota R_{f,t}$
- **Select** the sector/need n' with the largest excess demand $Y^x_{n,t}$
- **Develop** a new prototype with stochastic quality $q_{n',f,t} = f\left(\frac{\vartheta}{1-|n-n'|}\right)$
- Add to the prototypes basket
- **Market** a new product with probability $f\left(-\frac{\theta}{\Delta Y_{f,t}}\right)$, moving to a new sector/need only if competition pressure is lower

Income structure

D–1 Income distribution

- A **minimum wage** w^m is negotiated at the macro level
- Exponential wage structure along the organisational pyramid

$$
\begin{aligned}
w_t^1 &= \omega w_{t-1}^m \\
w_t^2 &= b w_t^1 \\
&\vdots \\
w_t^\Lambda &= b^\Lambda w_t^1 .
\end{aligned}
$$

  ω: firm bargain; b: executive multiplier
- Executives receive **bonuses** ψ^I from **residual** profit shares

Income classes and evolution of consumption

D–2 Consumption patterns

Consumption level differs by **labour/income** class.

- Each class z is populated by the workers of a tier with the respective wage and bonus
- Consumers in the same class share the same income, **expenditure shares**, and **preferences**.
- Class expenditure is shared among the needs that can be satisfied by the products currently supplied
- Expenditure shares $c_{n,z}$ change across classes: satiation

$$c_{n,z} = c_{n,z-1}\left(1 - \eta\left(c_{n,z-1} - \bar{c}_n\right)\right)$$

$\bar{c}_n$: an asymptotic value; η convergence (satiation) speed

- We assume a need = a consumption category

Consumer behaviour

- For each need, given the **perceived** characteristics of a good $i^*_{f_n,m} = N\left(i_{f_n,m}, \sigma^i i_{f_n,m}\right)$ (quality and price), a consumer selects all the firms that offer a good with **equivalent** values

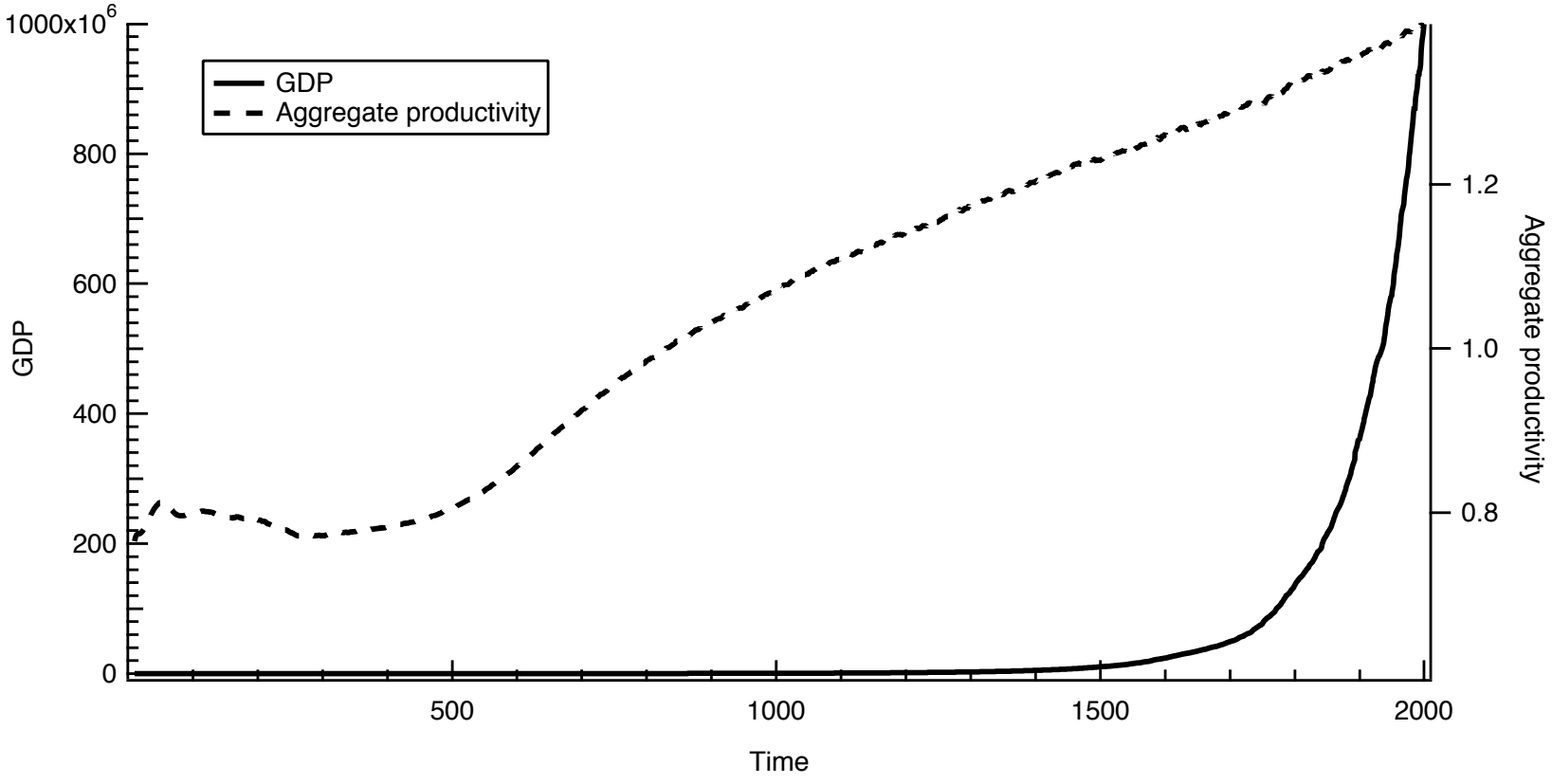
$$i^*_{f_n,m} \equiv i^*_{B_n,m} \Leftrightarrow |i^*_{f_n,m} - i^*_{B,m}| < (1 - \upsilon_{z,m}) \cdot i^*_{B,m}$$

  $\upsilon_{z,m}$: tolerance level
- The tolerance with respect to *less–then–optimal* quality on each characteristic defines consumer class preferences.
- Total purchases close the model: firms sales.

Results: the initial conditions

1. 100 manufacturing firms initially differ only with respect to good's quality
2. 2 Manufacturing sectors/needs
3. 2 Income classes, 10 overall needs
4. Firms hierarchical structure (number of tiers and wage differences across tiers) reflects empirical observation
5. Moving along income classes the tolerance towards *good's quality* reduces, and income elasticity decreases (*price*)
6. Asymptotic consumption share: UK top income centile figure
7. Initial consumption share: symmetric figure
8. Sufficiently fast changes in consumption share figure
9. Averages over multiple runs controls for random effects

Aggregate dynamics: GDP level & productivity

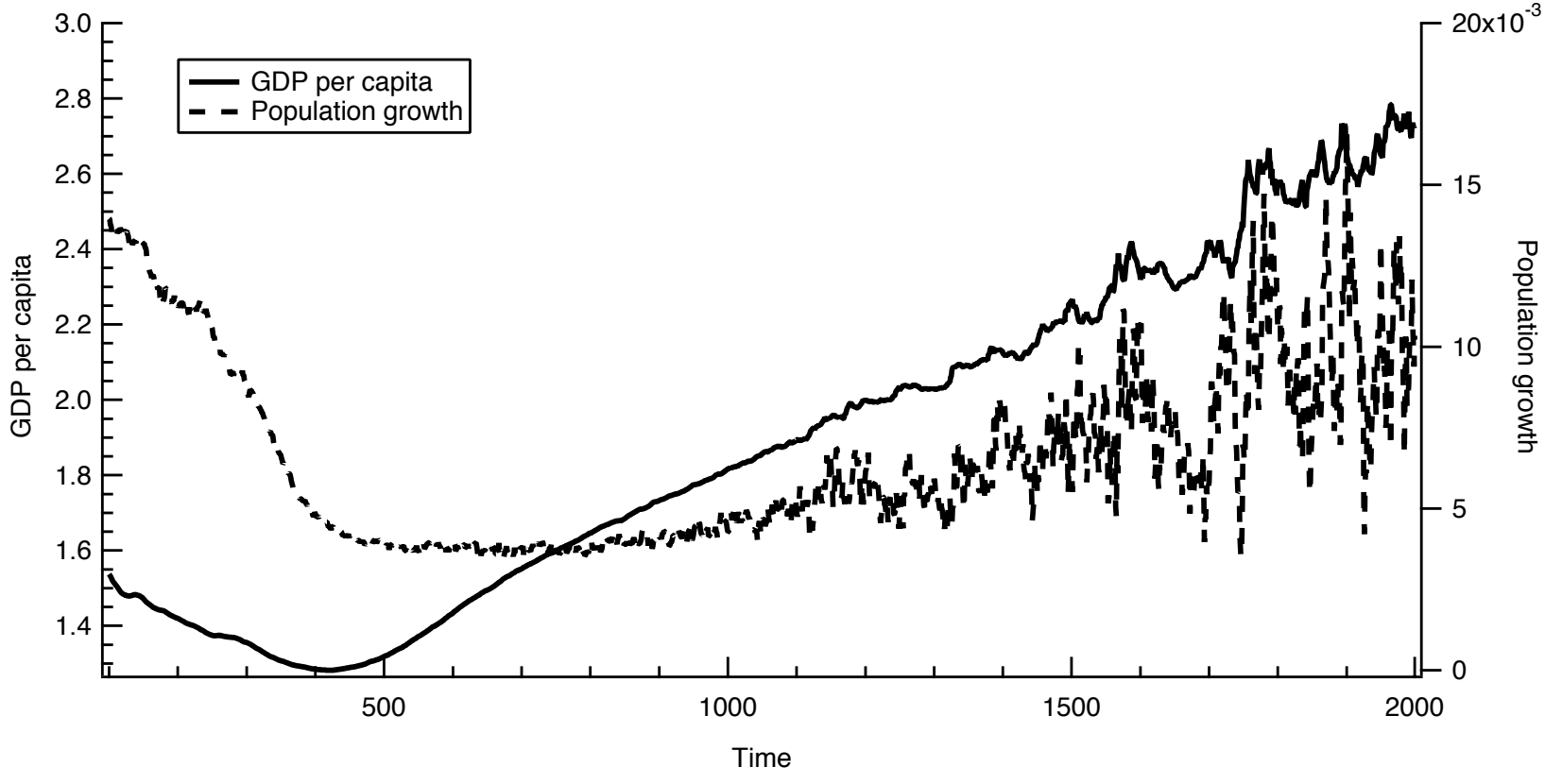


Pre- and post-Malthusian growth Scale

(1) Pre take-off: Stagnant GDP, low (increasing) mkt concentration, **increasing Productivity**

(2) Post take-off: Cumulative causation: ↑ Prod, ↓ Price, ↑ D, ↑ Investment, ↑ Firm size, ↑ Population & Consumer heterogeneity.

Aggregate dynamics: Population and per capita GDP

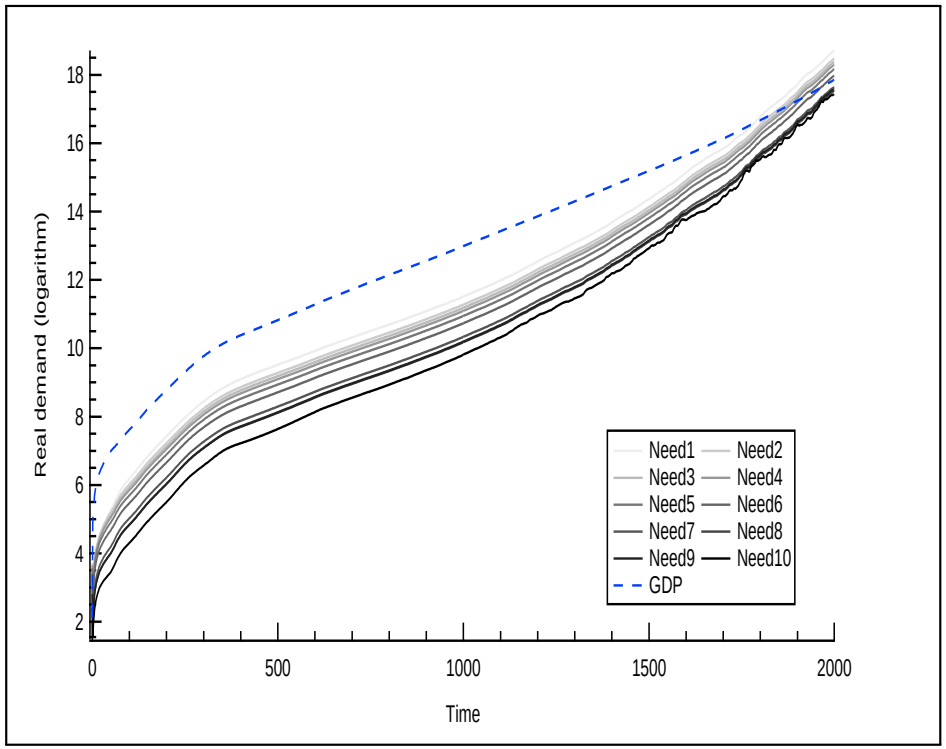


Preparation to take-off

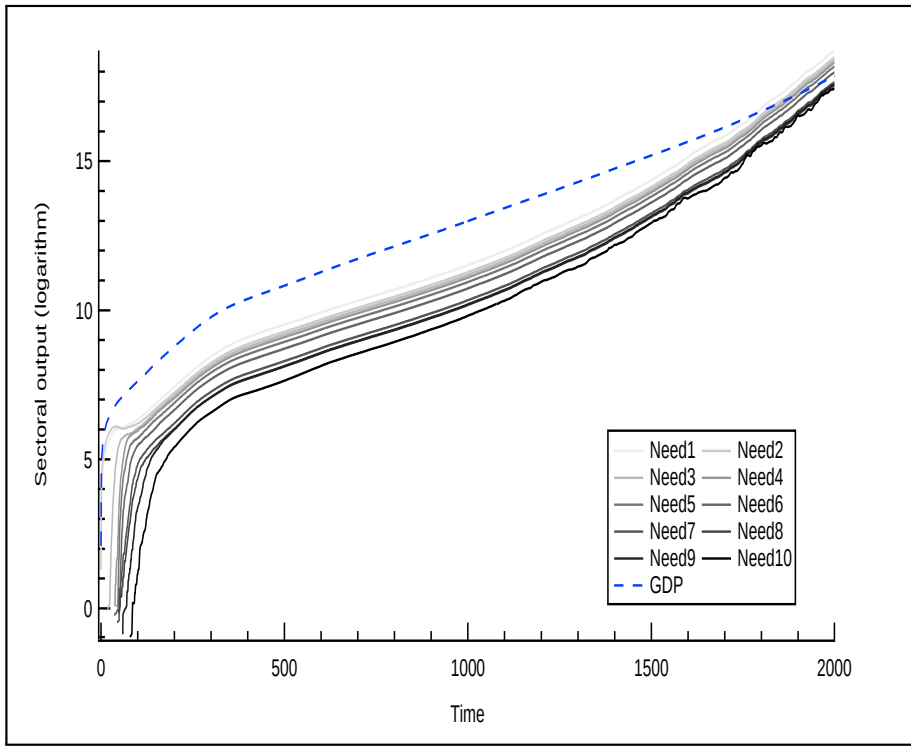
(1) Aggregate productivity accompanied by constant population growth rate

(2) Increase in real wages (but not nominal)

Sector dynamics: Potential demand and Sales



(**a**) Potential sectors demand



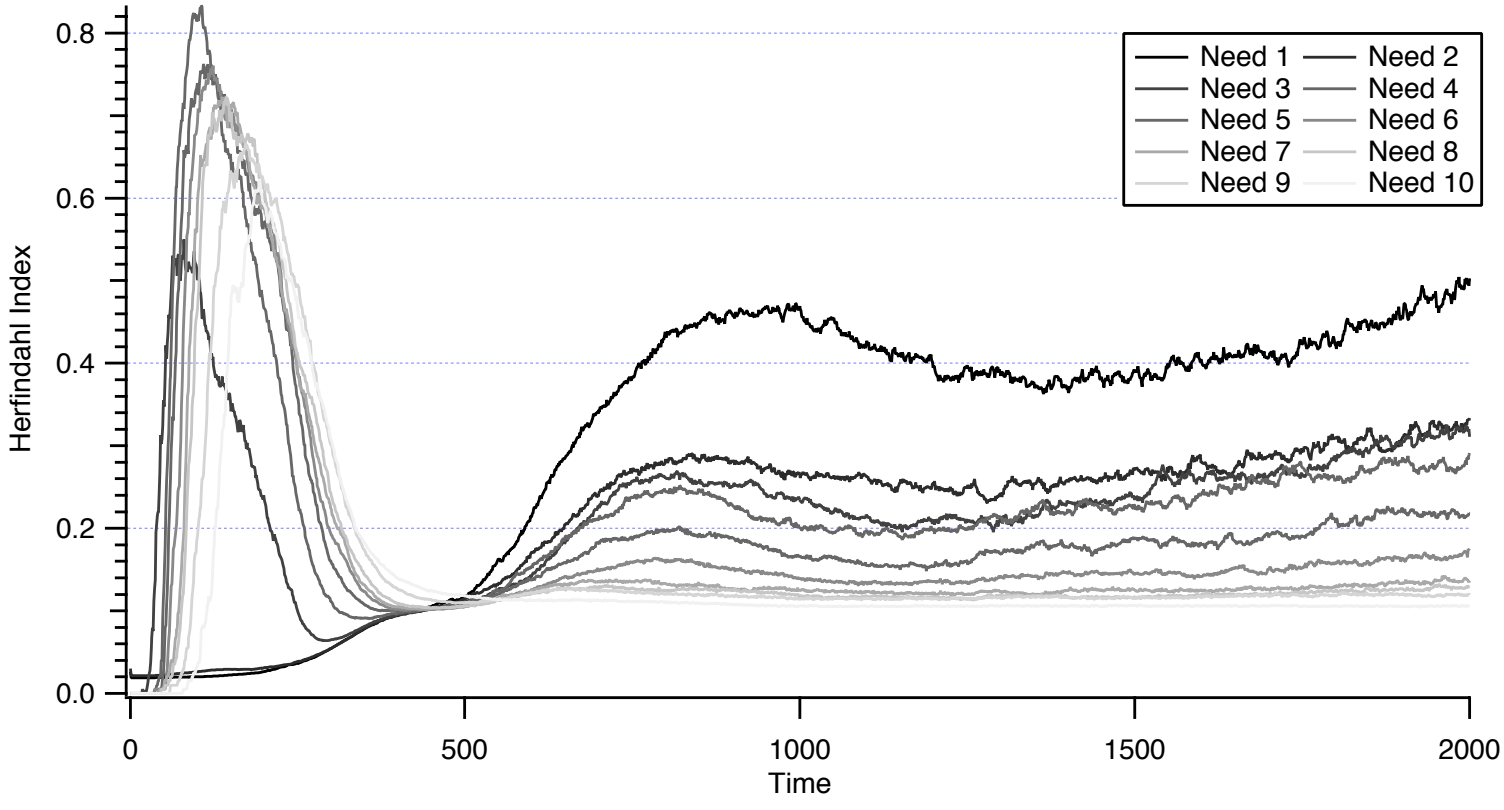
(**b**) Sectors sales

Emergence of new goods and convergence of sector sales

(1) ↑ Firm size, emergence of classes, ↑ D new goods
(2) Basic needs main component of demand (population share)

[See actual figures]

Industrial dynamics: Market concentration

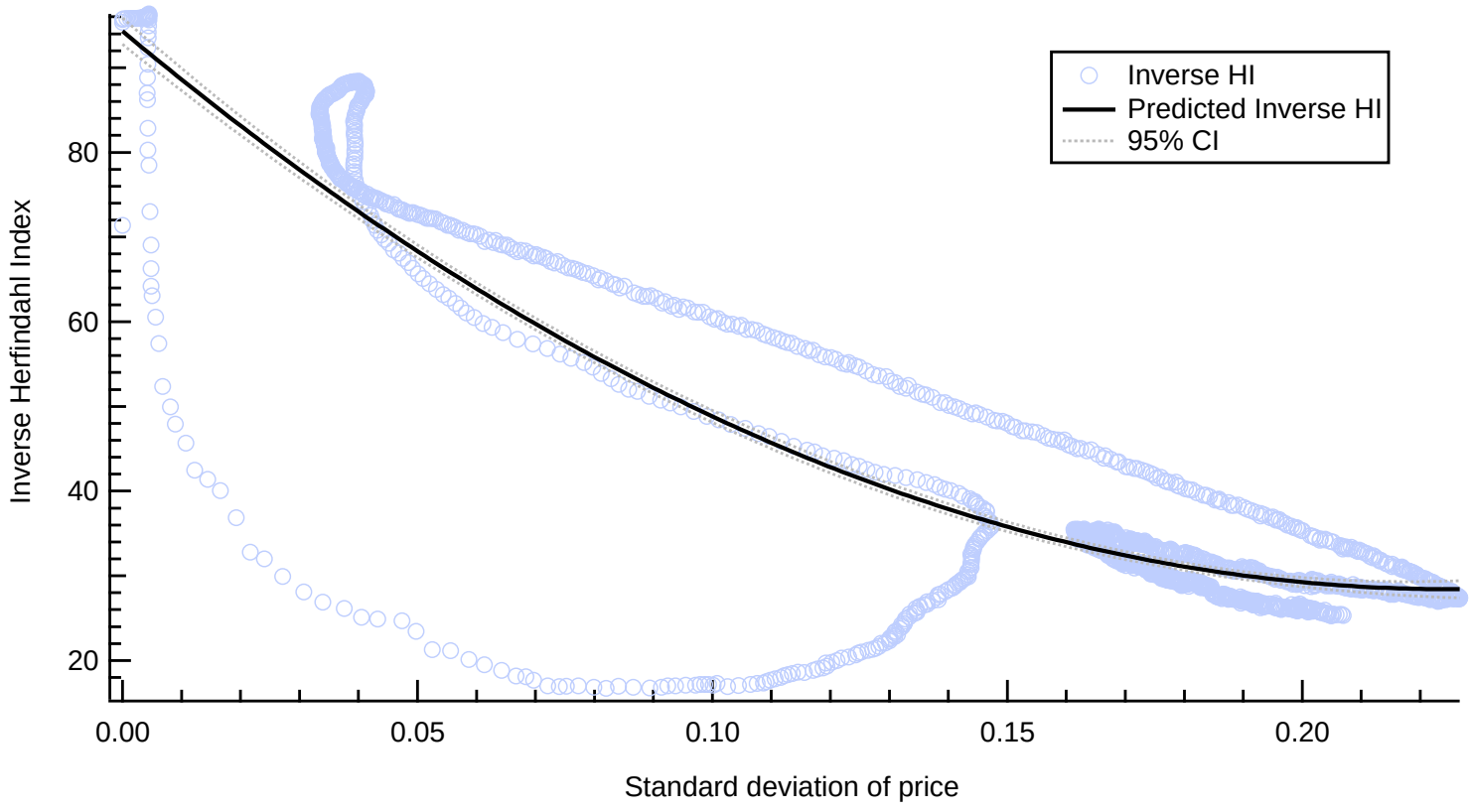


Three phases of market concentration, different across sectors

(1) (i) first entry (large concentration); (ii) increase in competition; (iii) price competition

(2) Price competition tougher in basic needs: stronger concentration

Micro dynamics: price variation and market concentration



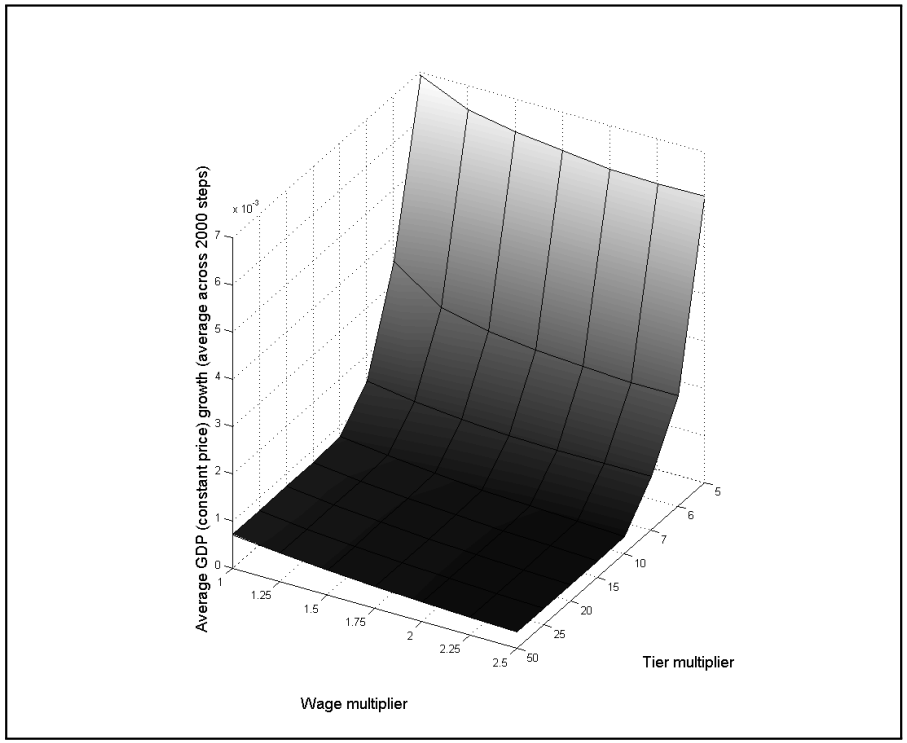
Selection of firms on price and quality sustains growth

(1) Initially price differences. When new classes emerge price & quality
(2) Selection, ↑ Firm size, ↑ D & variety, ↑ I, ↑ productivity, ↑ C, ↑ Selection

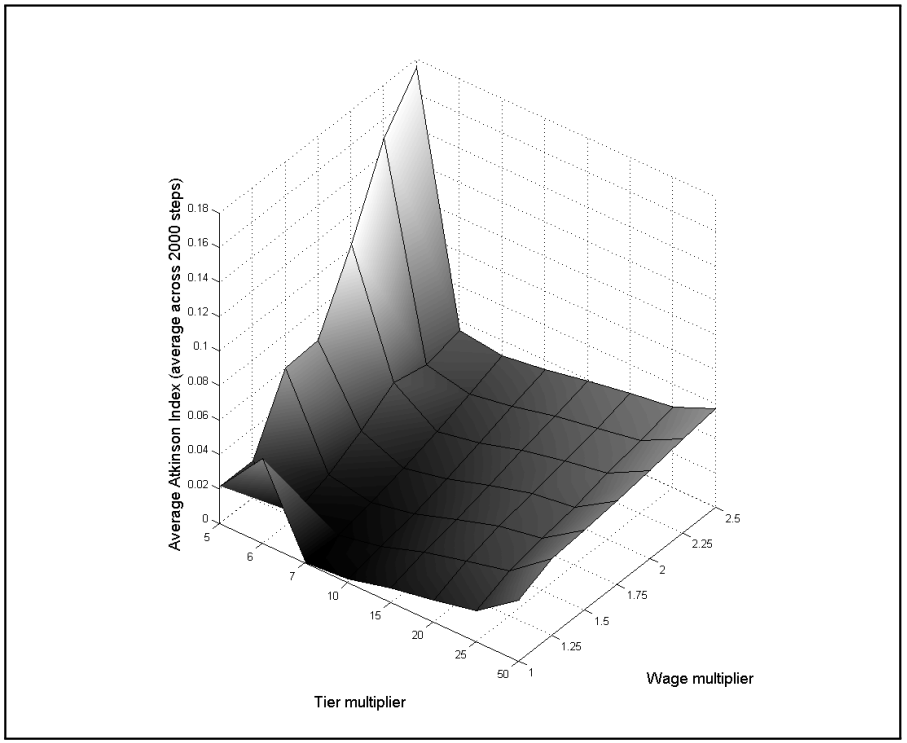
Organisation and income structure

- Flat Vs. pyramidal organisation: $\downarrow \nu$
- Uniform Vs. skewed compensation: $\uparrow b$
- Supply: increase cost (workers) and emerging heterogeneity
- Demand:
  - $\downarrow \nu$: increase demand and its heterogeneity
  - $\uparrow b$: increase income classes disparities (demand of higher classes)

Organisation and income structure



(**a**) GDP growth



(**b**) Atkinson index

Increase in organisational complexity and wage disparities [Ciarli et al., 2010]

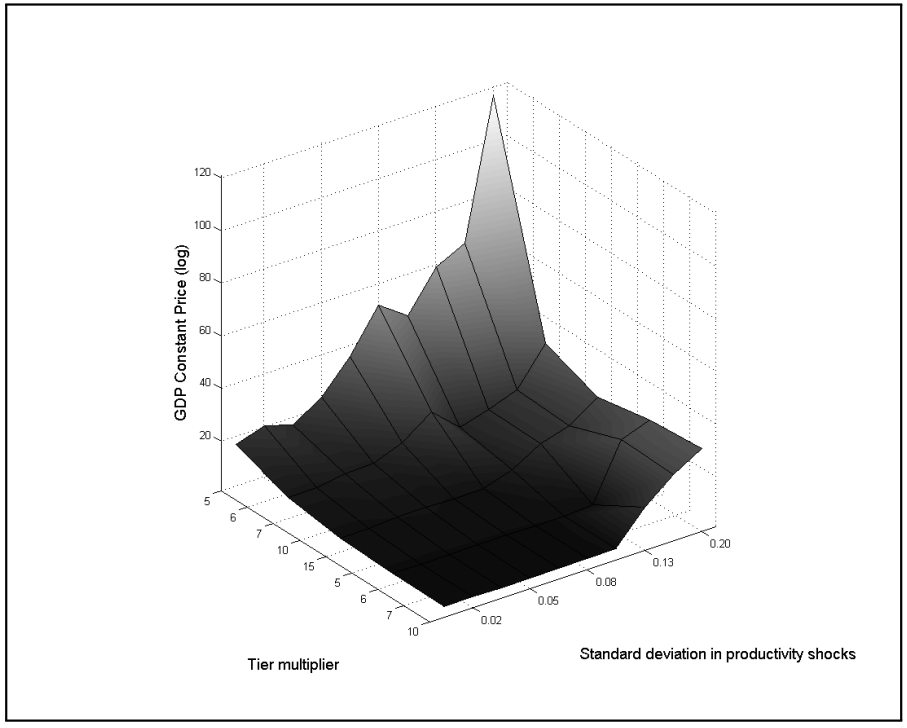
(i) number of layers: always ↑ growth and reflects on ↑ inequality (non linear) $\Longrightarrow$ demand has a stronger effect.

(ii) wage disparities: ↓ growth and ↑ inequality: difference between prices and minimum wage

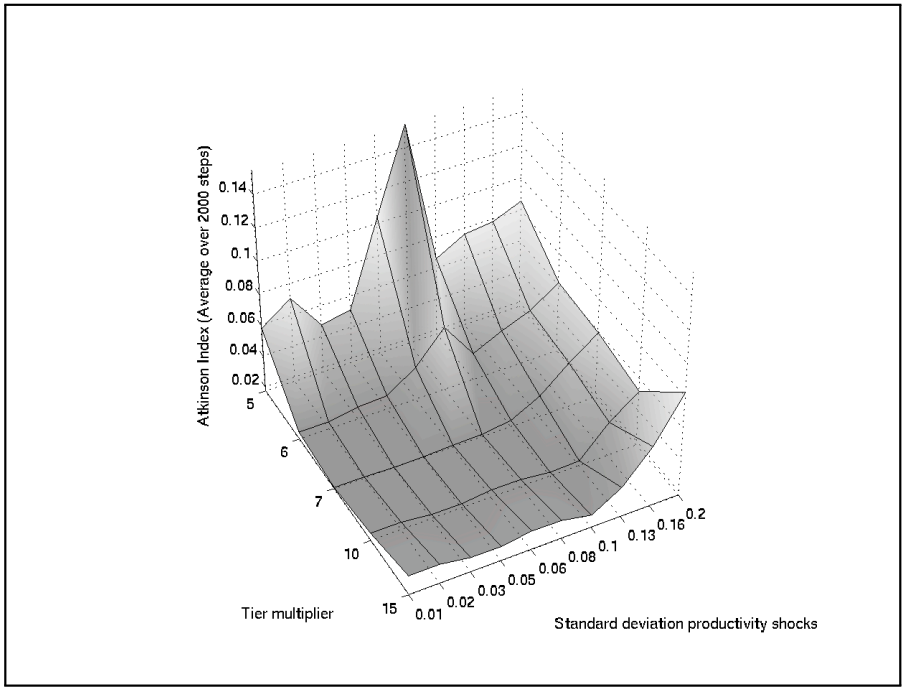
Organisation and production technology

- Flat Vs. pyramidal organisation: $\downarrow \nu$
- Increased process technology: $\uparrow \sigma^a$
- Supply:
  - $\downarrow \nu$: increase cost (workers) and dynamic heterogeneity
  - $\uparrow \sigma^a$: decrease cost (workers) and increase dynamic heterogeneity
- Demand:
  - $\downarrow \nu$: increase consumers and their heterogeneity
  - $\uparrow \sigma^a$: reduce consumers and the cost of goods

Organisation and production technology



(**a**) Log GDP at constant prices



(**b**) Atkinson index

Faster change in production technology and organisational complexity [Ciarli et al., 2010]

(i) ↑ GDP via effective demand: ↓ ν → ↑ D → ↑ I → ↑ Agg. prod;
↑ σ^a → ↑ Firm Prod → ↑ D → ↑ I → ↑ Agg. Prod
(ii) increase inequality, in a non linear way (↑ output ↑ workers ↓ agg prod ↓ profit distribution).

Innovation dynamics & evolution of demand

- Structural change in product/sectoral composition
  - Emergence of new needs (sectors) on the supply side: structural ch. in product variety has a strong positive effect on GDP Figures
    - Quick diffusion of new needs ↑ demand ↑ output ↑ speed of change of demand composition
  - Variety in innovation result (product quality) has a marginal positive effect on GDP Figures
  - Speed at which new products are sold in the market, modifying both the product composition and quality, has a positive effect on GDP growth Figures
- Structural change in demand: faster convergence to expenditure shares concentrated on luxury 'needs' has a negative effect on GDP Figures
  - Demand and Supply distribute across markets ↓ firms' concentration
  - ⇒ No time for development of industry

Summing up model properties

- Initial stagnant GDP, consumer homogeneity, low productivity, few markets, low concentration of production: slow increase in population and demand
- Slow increase in firm size: above a critical level increase firm concentration and consumer heterogeneity
  - Product innovation: product variety and market size
- Price and quality dispersion: spur investment and productivity increase, prices reduce
- Increase in real wages and aggregate demand: cumulative causation
- Take-off

Some conclusions from the model

- Long–run growth model in which we consider many aspects of interrelated structural changes at the microeconomic level
- The structure of production and demand has a strong and articulated effect on the relationship between growth and income distribution
  1. *Organisation of production* generates price dispersion and income classes
  2. *Technology of production* generates larger demand, p dispersion and I
  3. *Composition of production*: consumers select and increase the demand matching unsatisfied needs (markets)
  4. *Income structure* determines different consumption preferences, consumption shares and firms selection
  5. *Consumption preferences* & *consumption shares* generate oligopolistic competition $\Rightarrow$ Profits
- In our model we show how these structural changes co-evolve endogenously

Research questions — *answers*

Structural change

Articulated changes in $\neq$ components of the economy at $\neq$ levels
Often indistinct from growth/development determinants

Structural change & growth

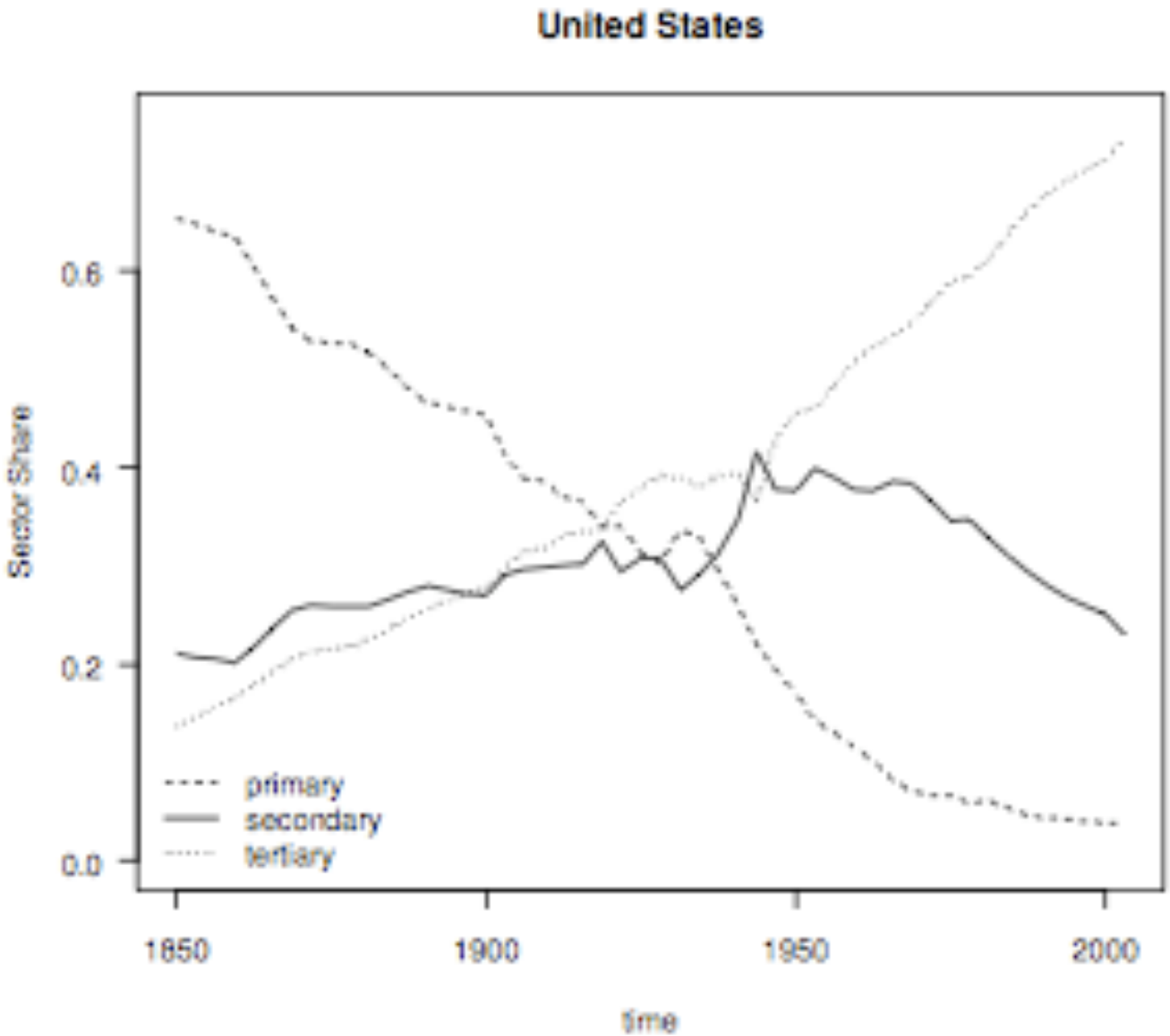
Growth and structural change co-evolve
Mainly represented as shifts from low income and unproductive agricultural society to high income and productive industrial society
But there is much more going on (organisation, demand, product innovation...)

Research questions — *answers*

Micro models

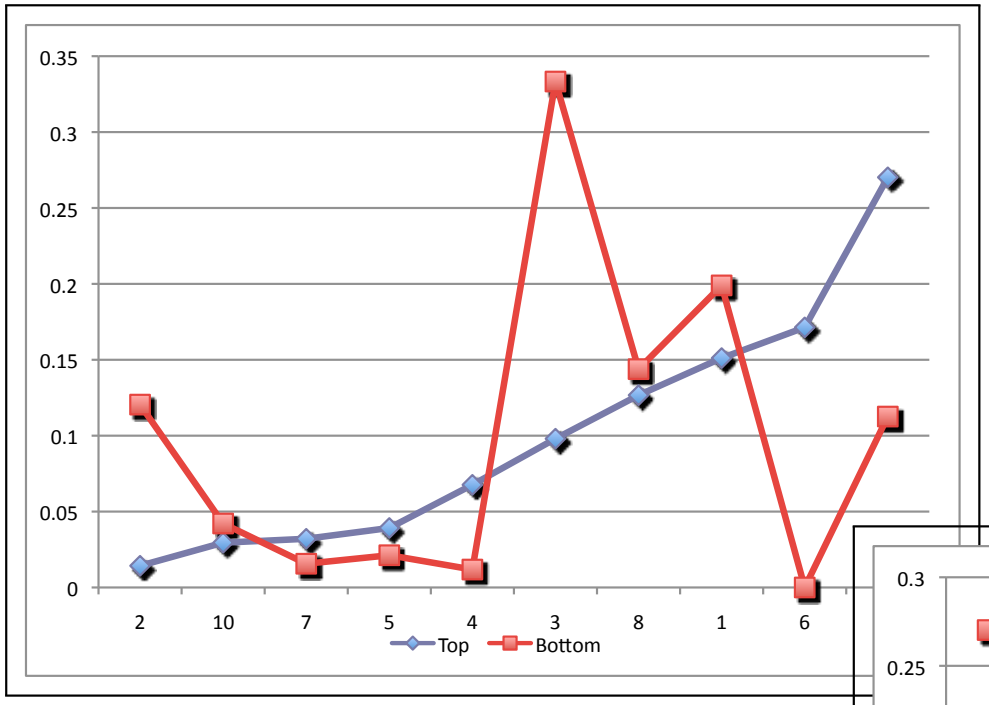
Necessary: it is where structural change occurs
Analyse relevant features of agents' choice, interaction, regulation (how are these affected by institutions?)
Computational models: define complex and non linear relations, and analyse emerging properties

Long term change in Employment shares US



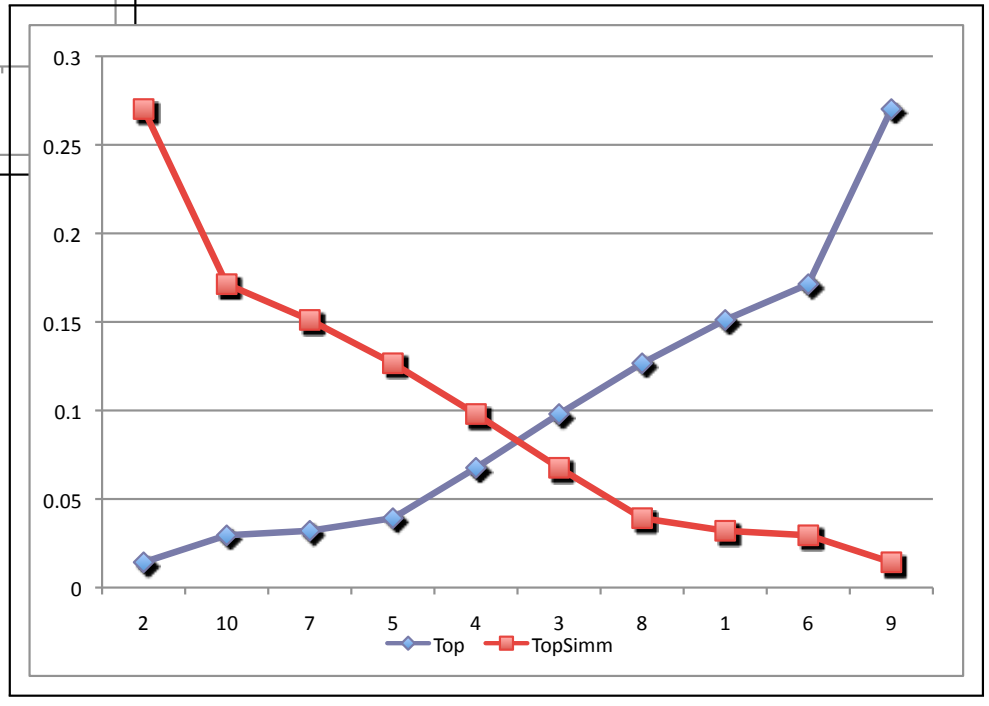
Source: [Dietrich and Krüger, 2010] Structural change

Expenditure shares ordered by UK top centile



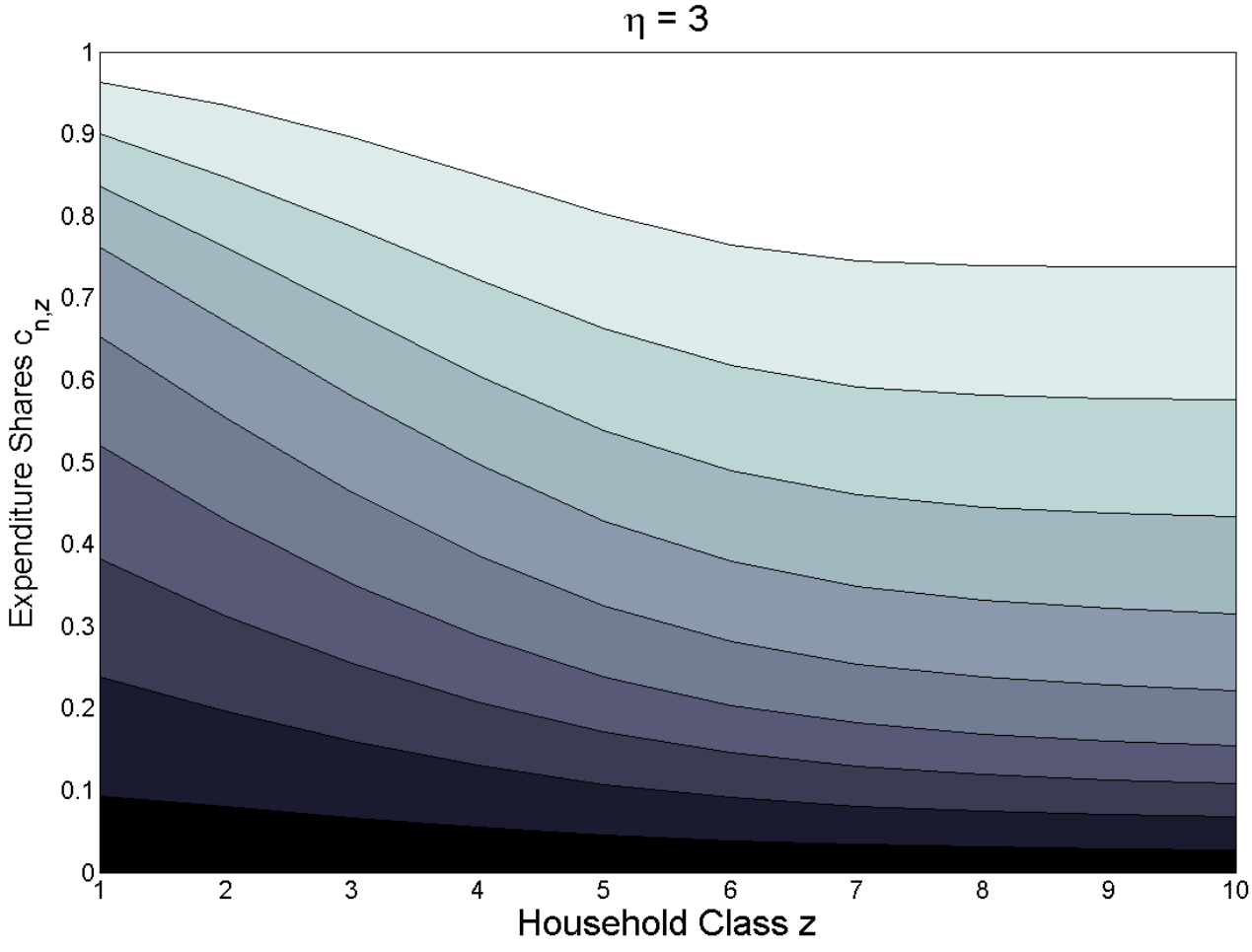
(**a**) Original distribution

Init



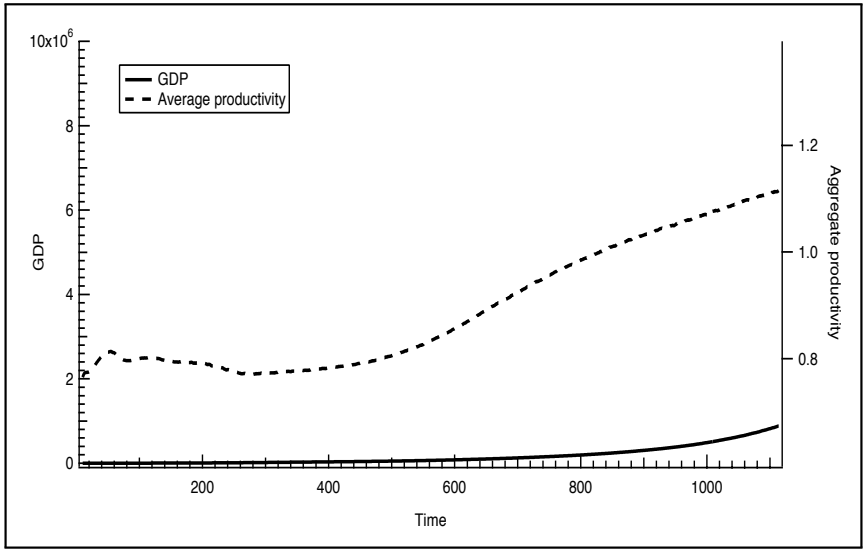
(**b**) Symmetric distribution

Implicit Engel curves: evolution of consumption shares

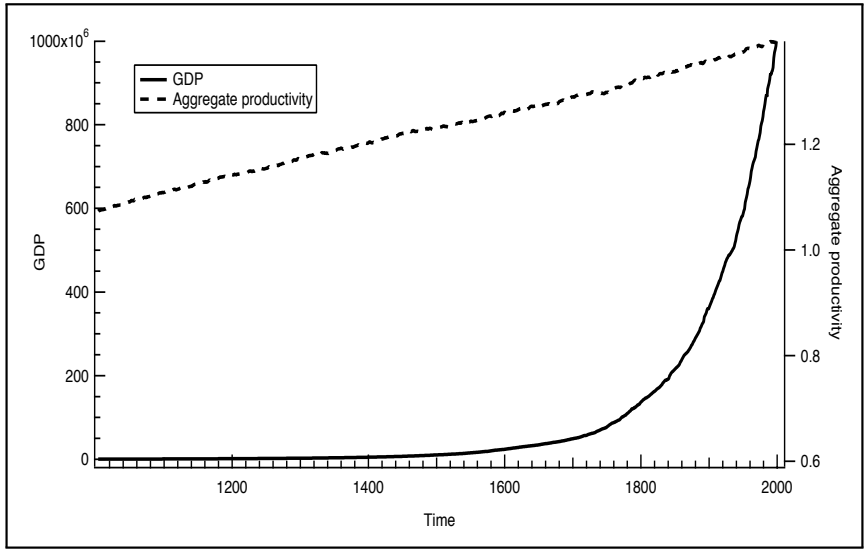


Change in consumption share for $\eta = 3$ and ten consumer classes. In the model consumption classes emerge endogenously Init

Research width: emergence of new needs



(**a**) Pre take-off

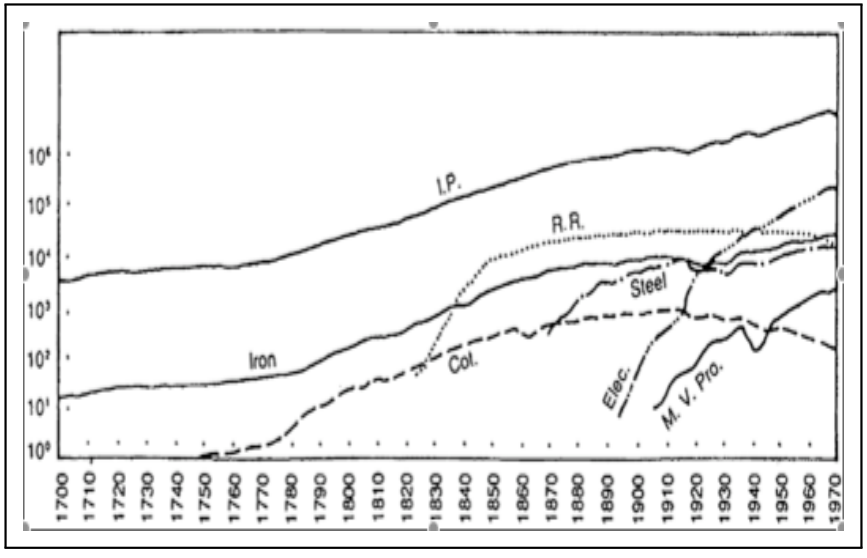


(**b**) Post take-off

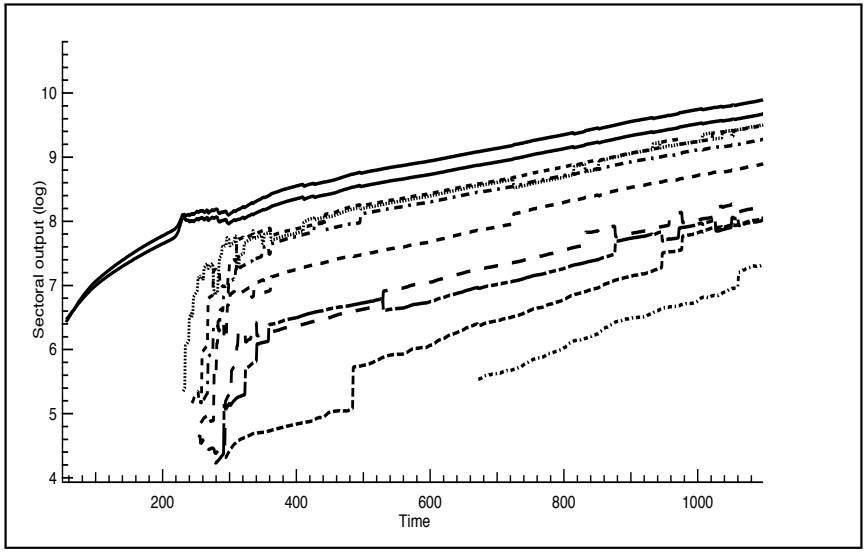
Pre- and post–Malthusian growth re-scaled

Back

Sectoral production in UK



(**a**) Rostow 1978



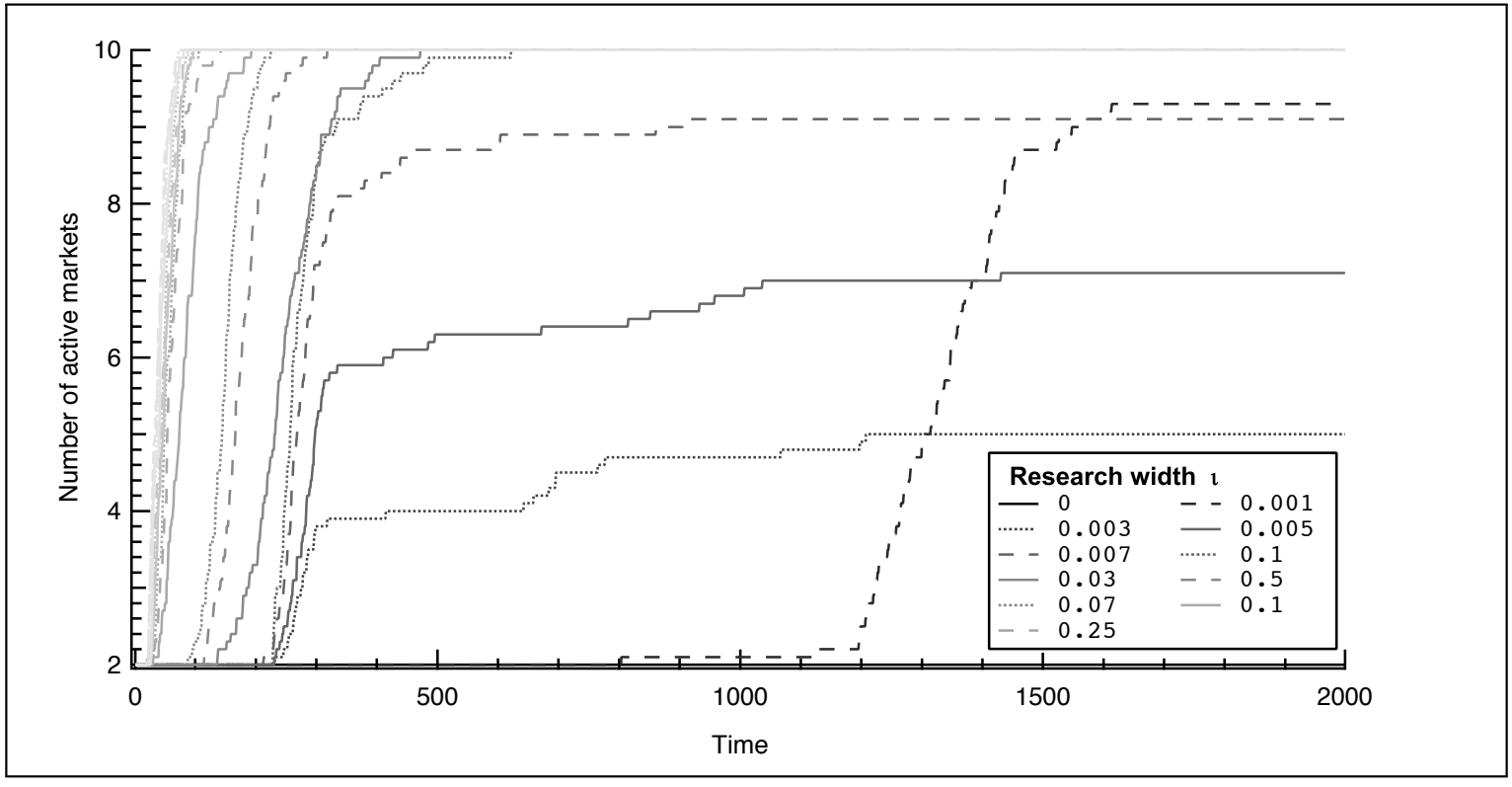
(**b**) Model simulations

Source:[Aoki and Yoshikawa, 2002]

A qualitatively similar pattern of sector emergence

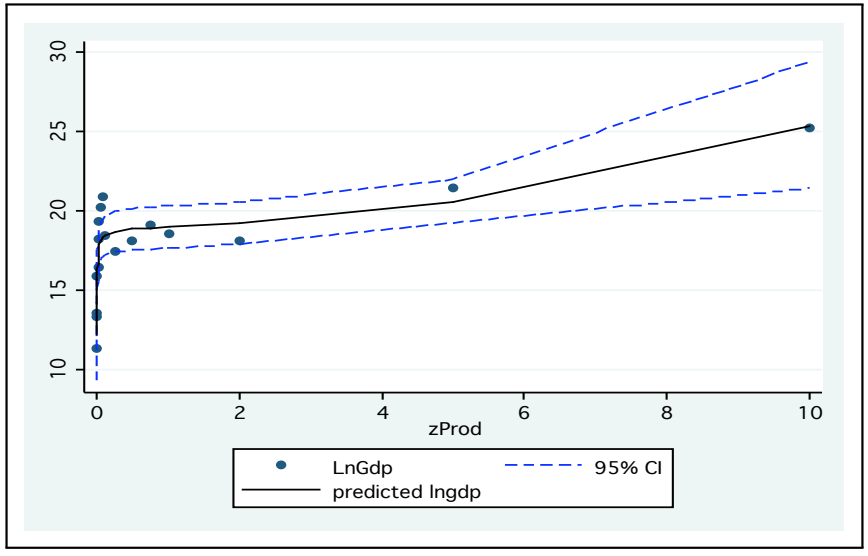
(1) Initial strong raise
(2) Convergence across sectors, and some overlapping [back]

Research width: emergence of new needs

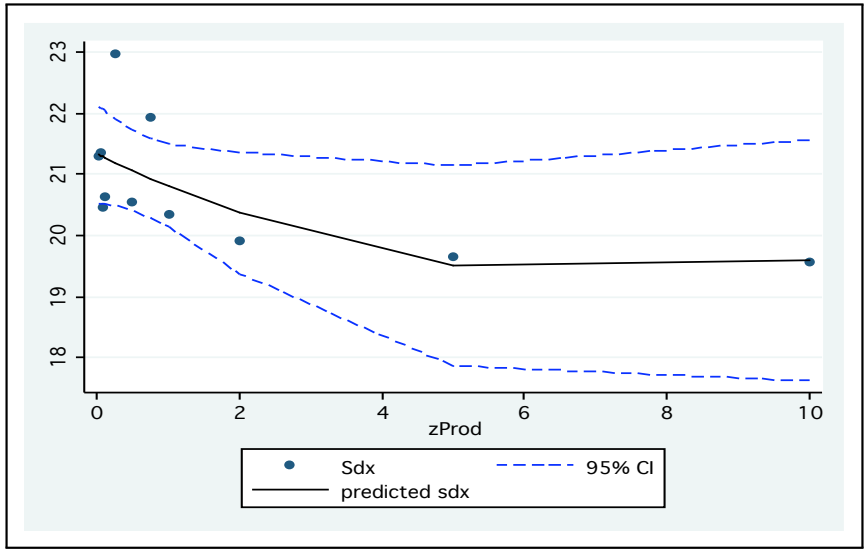


Some needs can be satisfied by consumers only after a large number of periods (slower emergence of variety)
How does this affect growth?

Research width: emergence of new needs



(**a**) GDP Vs width



(**b**) Quality variety Vs width

Broader research width

— Increases GDP, especially for low width
— Reduces quality variety

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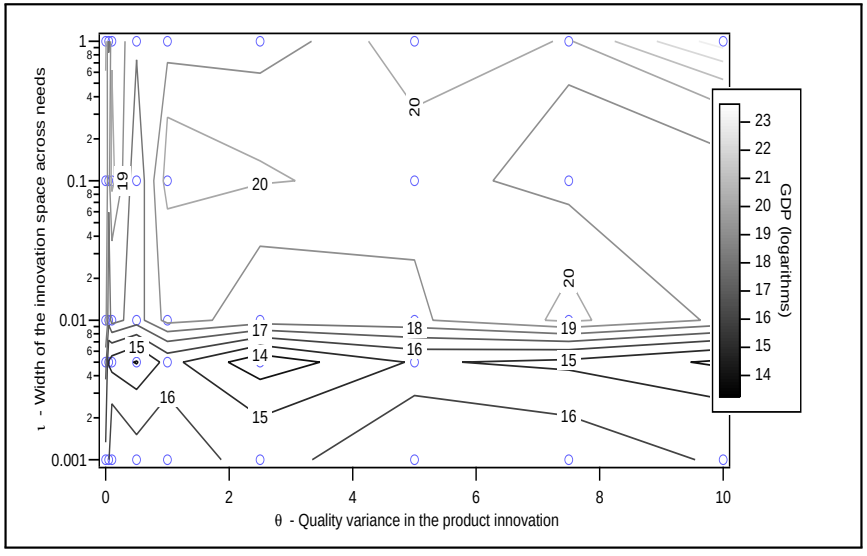
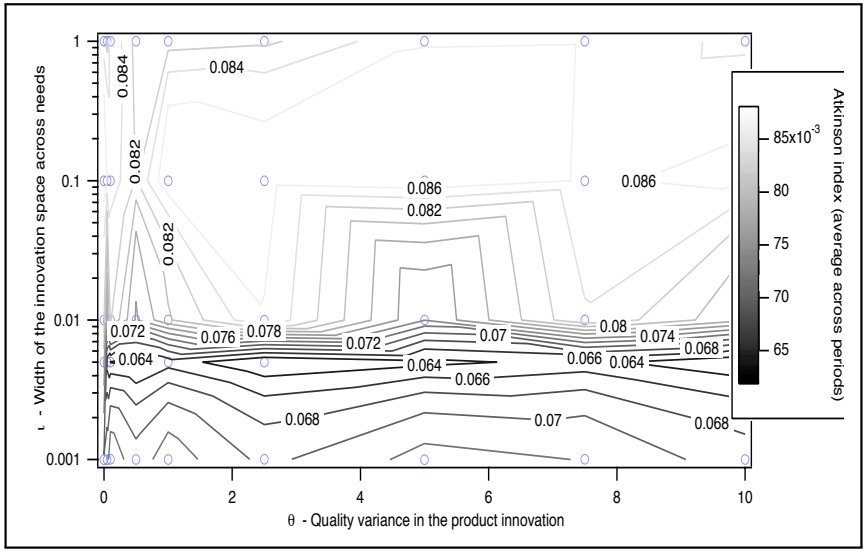
Variety in the innovation result



(**a**) GDP



(**b**) Atkinson index

An increase in the variance of the quality change of innovations

— Increases both GDP and inequality
— But only marginally with respect to the emergence of needs

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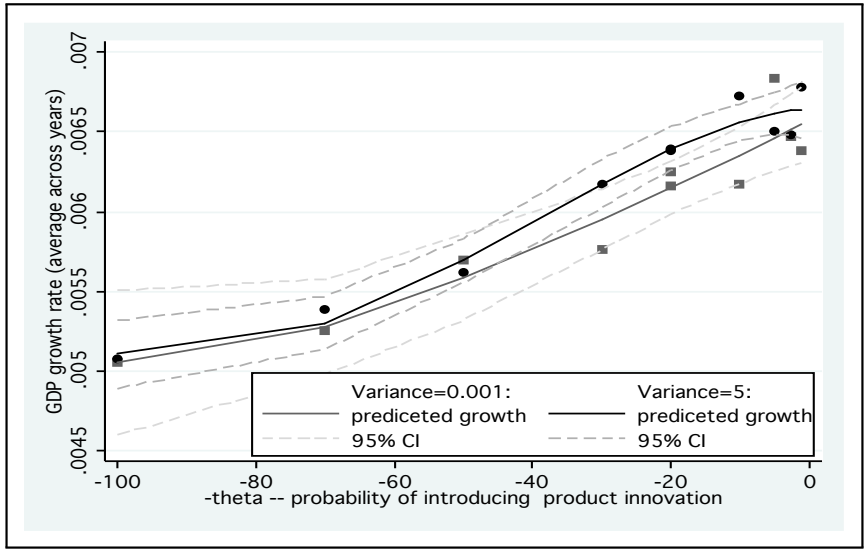
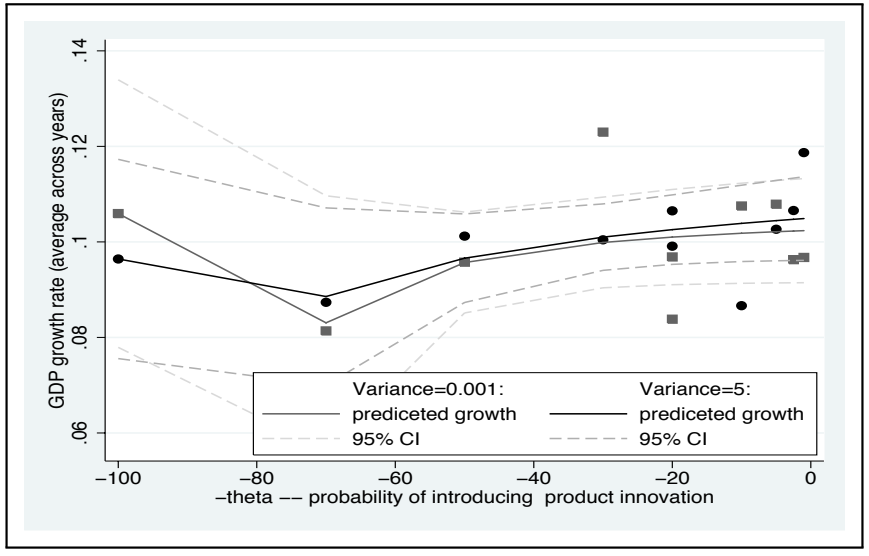
Rate of innovation emergence



(**a**) GDP



(**b**) Atkinson index

Accelerating the rate which the prototypes are marketed

— Increases both GDP and inequality
— Have a higher impact for larger innovation variety

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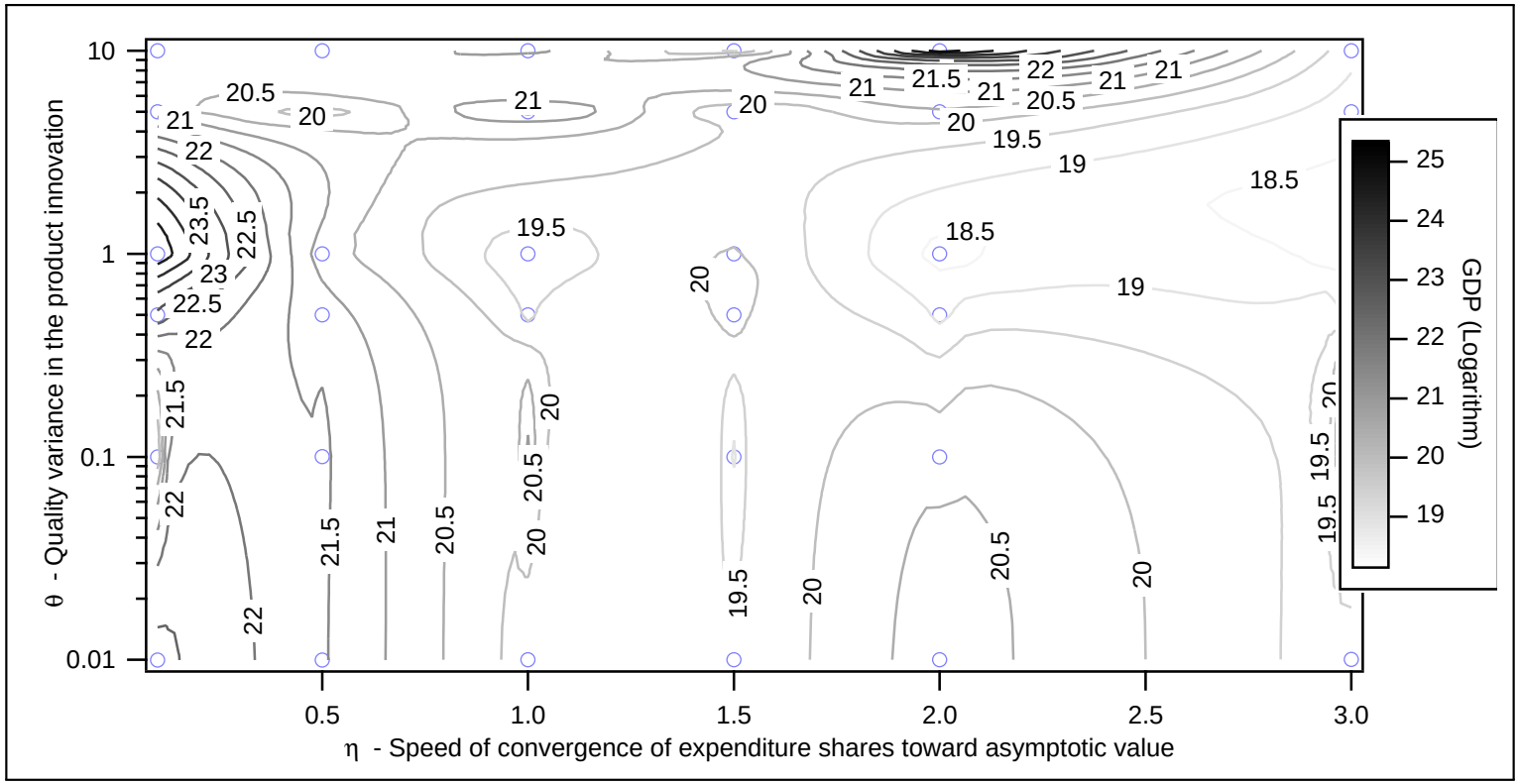
Demand side: changes in expenditure shares



Increasing the speed at which richer consumer classes move to 'luxury' needs

Has a negative effect on growth!!
Only partially mitigated by larger innovation variety

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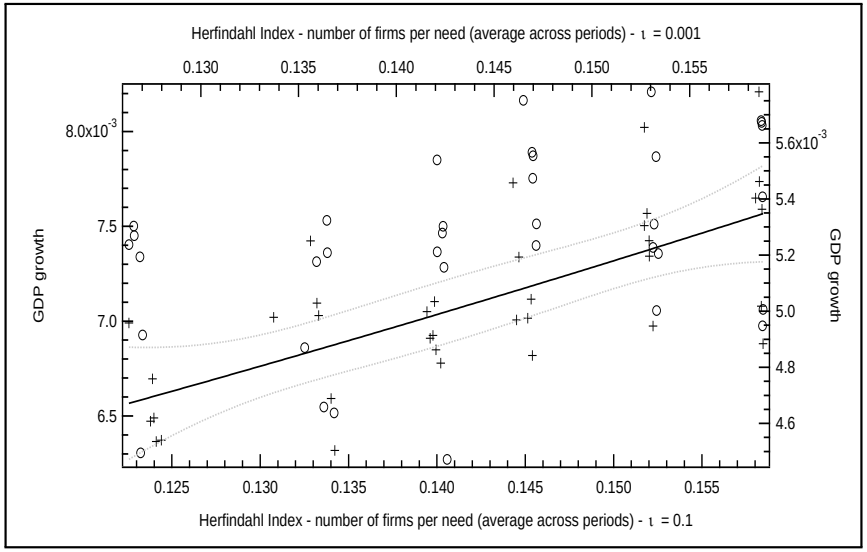
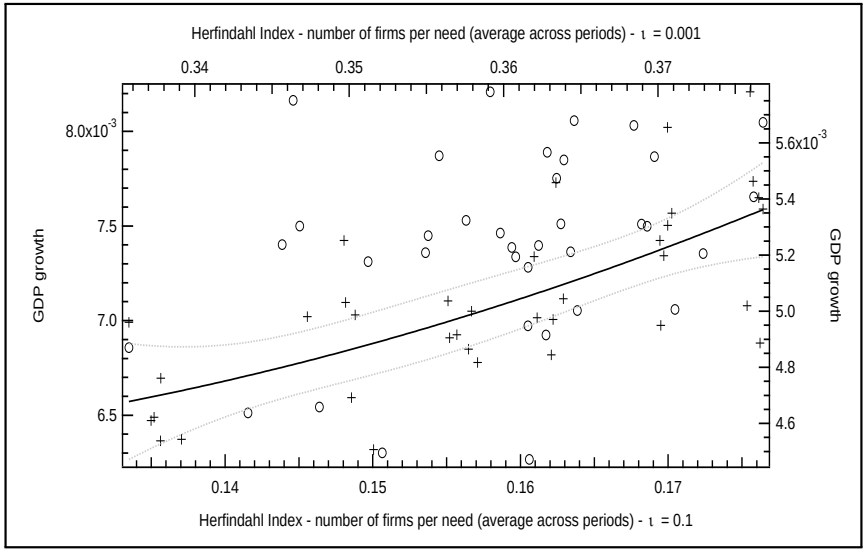
Changes in expenditure shares and GDP: an explanation



(**a**) Demand market concentration



(**b**) Supply market concentration

For high speed of convergence of expenditure shares, demand and supply distribute across markets

— Larger concentration of demand or supply in few markets increases firms' market shares concentration

— Concentration of production increases cumulative causation

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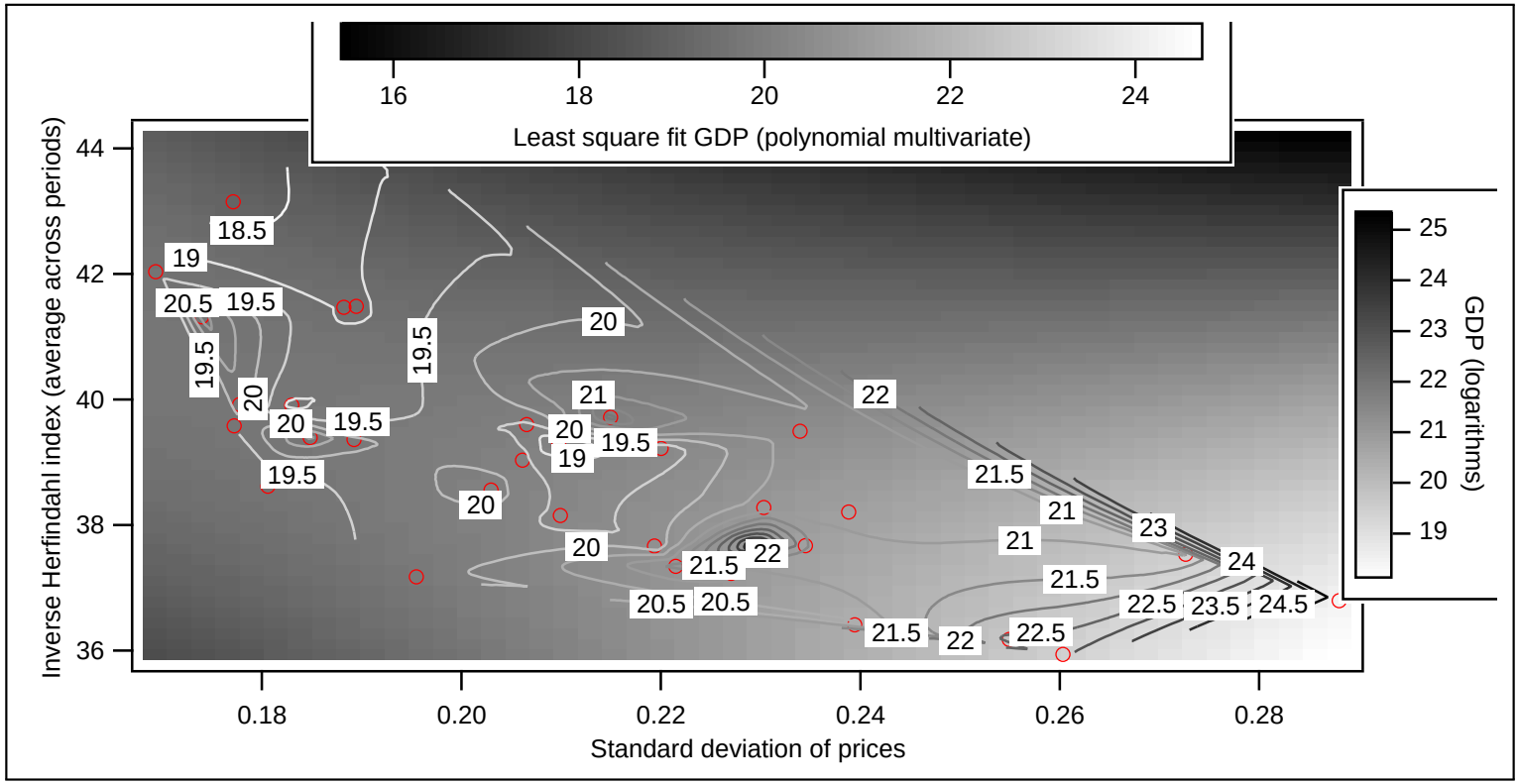
Changes in expenditure shares and GDP: an explanation



Firms market share concentration and price differentiation are positively correlated

— They are both correlated with a higher level of output
— They both predict a higher level of output with a high level of confidence

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